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CONTROL OF THE JAPANESE BEETLE ON FRUIT AND SHADE TREES

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INTRODUCTION

Since the Japanese beetle was first discovered in the United States in 1916, it has increased greatly in numbers in certain localities in New Jersey and Pennsylvania. Many of the important food plants grown in the heavily infested area are favorites of the beetle. Because of the economic importance of many of these plants, it was necessary to devise some method of protecting them from injury by this insect. The information given in this circular is based on recent experimental work conducted in the infested area adjacent to the point of original discovery. The various measures specified herein are primarily for use in the heavily infested areas shown in Figure 1. Unless serious injury resulted from beetle feeding the preceding year, sprays for the control of this insect are not necessary.

LIFE HISTORY AND HABITS

The Japanese beetle passes the winter in the larval or grub stage in the soil. About the last of May and early in June the insect changes to the pupa, in which stage it remains for 8 to 20 days. From this pupa the full-grown beetle emerges. Emergence generally begins about the middle of June and continues over a period of from six to nine weeks, the peak occurring shortly after the middle of July during a normal year.

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The adult beetle is a beautiful brightly colored insect about the size of a Colorado potato beetle, but on warm, sunshiny days it is more active than this well-known pest. The head and thorax are shining metallic green and the wing covers are reddish bronze tinged with

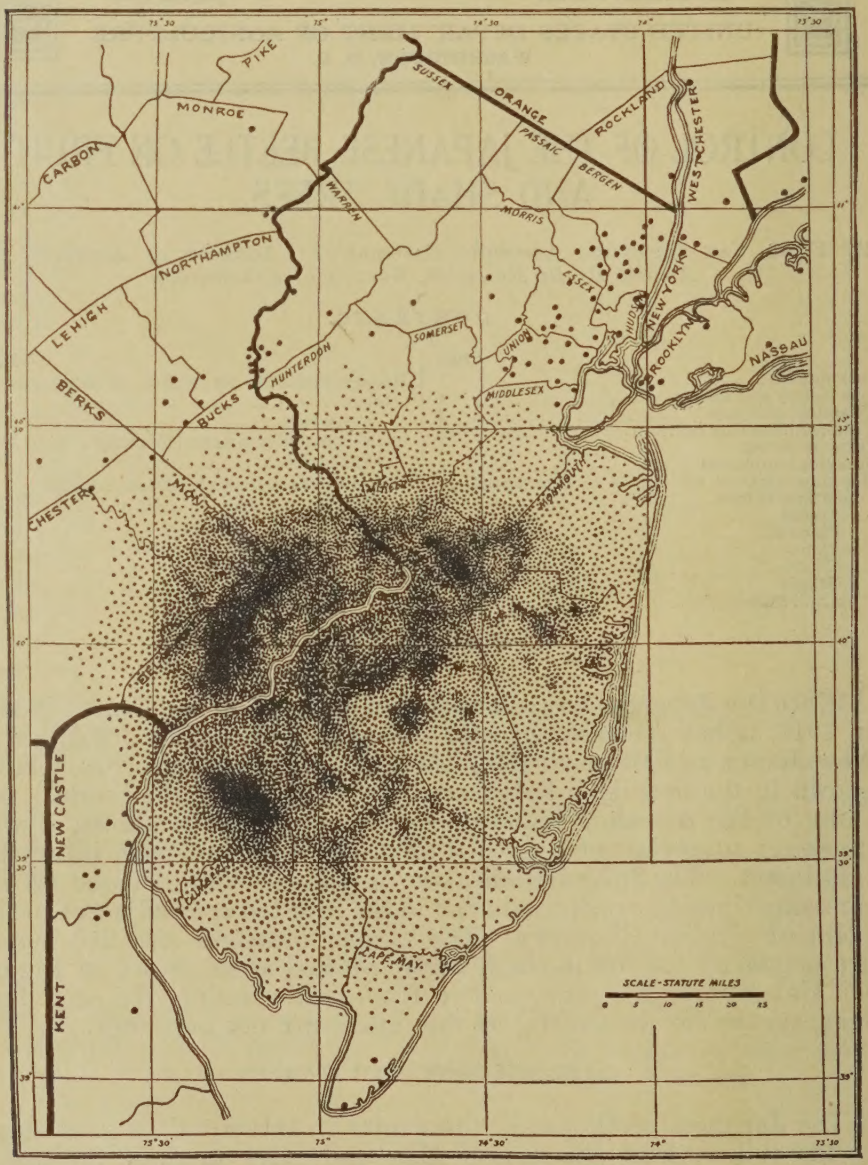

FIGURE 1.—Map of New Jersey and parts of adjoining States showing the status of Japanese-beetle infestation in 1931. The heavily infested area is indicated by the more stippled portions. The large scattered black dots show the known local occurrences of the insect in the part of the area of discontinuous distribution included within the map limits

green at the edges. On the sides and tip of the abdomen are short tufts of hair which resemble small white dots. (Fig. 2.)

The life period of the adult beetle ranges from approximately five to eight weeks, and during this time it feeds on leaves and fruits.

The female returns to the soil during certain periods to deposit eggs. The eggs hatch in about 12 days. The larvae remain near the surface of the soil to feed until the approach of cold weather, when they burrow deeper into the ground. There is only one generation a year. (Fig. 3.)

CHARACTER OF INJURY

The injury caused by the adult beetle is the result of its feeding on foliage and fruits. The leaves of trees are in part or wholly skeletonized; that is, the softer tissues of the leaf between the coarser veins are eaten. As the insect prefers to feed in sunny places, it first destroys the leaves at the top of the tree or plant. The remnants of the leaves soon turn brown and fall off, and a partial second crop of leaves is produced. Beetle infestations have been so severe at times that large shade and fruit trees have become completely defoliated within four days after being first attacked.

FIGURE 2.—The Japanese beetle. × 3

Early ripening fruits are especially attractive to the beetle. At times the beetles collect on early apples and peaches in such large numbers as completely to cover the fruit. The author once collected 13 tubs of beetles from 156 early peach trees in the vicinity of Moorestown, N. J., and within two days the trees were again heavily infested. Very little feeding by the beetle is sufficient to destroy an entire crop of early apples or peaches. Once the skin of the fruit has been broken by the insect's jaws, it has little market value.

FACTORS INFLUENCING CONTROL

The Japanese beetle is a difficult insect to control. There are several reasons for this: (1) The large number of insects found in the neighborhood of the crops to be protected; (2) the failure of the beetle to feed on poisoned plants; (3) the great attraction that the beetles have for each other; and (4) the large number of different kinds of plants upon which the beetles will feed.

One of the chief factors which make it possible to secure protection, in spite of the countless numbers of beetles, is the repelling effect

that the ordinary sprays have on the beetle. The beetle is controlled mostly by the prevention of feeding, and the term "protection" or "control" in this circular therefore refers to the repelling effect

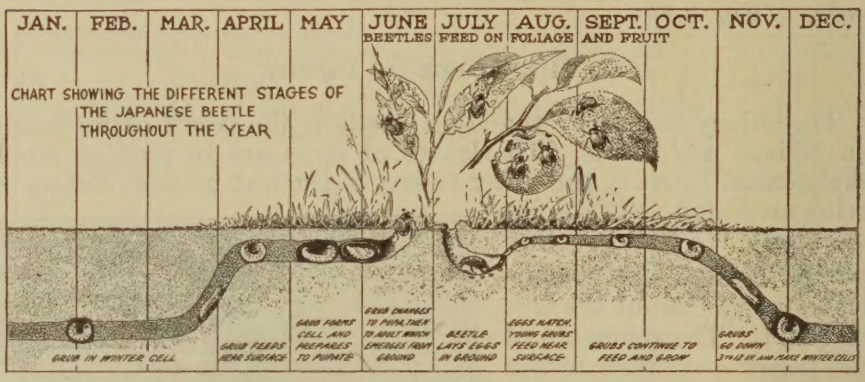

FIGURE 3.—Diagrammatic representation of the annual life cycle of the Japanese beetle

of the spray deposits on the plant rather than to the destruction of large numbers of beetles. Some feeding does occur, but unfortunately only about 30 per cent of the beetles which feed on the

FIGURE 4.—Unsprayed and well-sprayed foliage. This figure illustrates the deposit on foliage which is necessary to control the Japanese beetle

poisoned plant consume a toxic dose. The majority of beetles in the vicinity of sprayed foliage are repelled before alighting.

Thoroughness and timeliness of application of the sprays are more important in the control of this insect than is the ingredient used

in the spray. All portions of the plant should be covered with a film of the spray deposit. (Fig. 4.) Any uncovered area on foliage or fruit will be selected by the beetle for feeding. Since the beetle first attacks the upper portions of the plant, it is essential that these parts be well protected with a coat of spray. A much larger quantity of spray is necessary for combating this pest than is ordinarily employed by commercial fruit growers in the control of miscellaneous orchard pests in the vicinity of the original infestation. A 25-year-old apple tree approximately 20 feet high with a branch spread of 25 feet requires at least 18 to 20 gallons of spray solution evenly distributed over the foliage and fruit.

If any infestation of beetles is present or if the plant has already been injured, the problem of preventing further injury is more difficult. Therefore, the importance of applying the sprays before infestation or injury occurs can not be overemphasized. Since beetles will attract beetles, the secret of control is to apply the spray before the beetles are present in large numbers. In a normal year sprays should be applied by July 4.

SPRAY MATERIALS

Lead arsenate [1] plays an important part in the control of the Japanese beetle. It is the best known and most extensively used stomach poison for the destruction of insect life. It is comparatively safe to use on all types of foliage, remains on the foliage longer than any other stomach poison, mixes well with water, and on account of its fineness remains well in suspension. Its greatest advantage, however, is its high repellency to the beetle when used at a strength of 6 pounds to 100 gallons of water.

Ordinary wheat flour, averaging approximately 16 per cent gluten content, is added to the lead arsenate to increase its power of adhering to the plant.

Lead oleate coated lead arsenate, which is recommended in this circular particularly for shade trees and shrubs, is ordinary acid lead arsenate paste, containing approximately 55 per cent water, treated during manufacture with lead acetate and oleic acid to form a 2 per cent lead oleate coating of the lead arsenate paste. The spray was developed at the Japanese beetle laboratory during a search for a toxic material which the beetle would eat readily. Not only does the addition of the lead oleate increase the kill of beetles, but the material possesses good adhesive qualities.

Hydrated lime is a well-known commercial product made by slaking stone lime with water, either as such or in the form of steam. This should not be confused with a slaked lime. Where hydrated lime is substituted for stone lime, one-fourth of a pound more should be added for each pound of stone lime.

Calcium caseinate, a commercial mixture of casein and lime, has been widely advertised as an effective spreader for certain insecticides.

New Jersey dry mix is a fungicidal spray combination composed of finely ground sulphur and lime to which calcium caseinate has been

[1] Unless otherwise specified, the term "lead arsenate" as used throughout this circular refers to the dry form of acid lead arsenate.

added. The proportions of the materials in this mixture are as follows:

	Pounds
Finely ground sulphur	8
Hydrated lime	4
Calcium caseinate	½

All dry materials should be mixed in pails or buckets before being placed in the spray tank. Whenever flour is used, all the dry materials should be thoroughly mixed before any water is added; otherwise the flour will lump badly and cause difficulty during the spray operation. A small quantity of water should be added first and the mixture again stirred, after which sufficient water is added to make a thin paste. It can then be strained into the spray tank.

SPRAYING EQUIPMENT

For plants growing under commercial conditions the ordinary high-pressure power outfits in general use for control of other insects

FIGURE 5.—Spraying shade trees with high-power outfit. It is essential that the tops of certain varieties of trees be covered with a coating of spray to prevent injury by the beetle

and diseases can be employed. (Fig. 5.) These outfits are made with pumps of from two to four cylinders having a capacity of from 10 to 50 gallons per minute and operated by gasoline engines of from 4 to 15 horsepower. Often the pumps are operated by a direct hook-up with the tractor or truck drawing the sprayer. Only the best grade of high-pressure hose which is guaranteed against imperfections in workmanship and materials should be used and the working pressure under which the hose is to be used should be specified. The length will depend on the conditions under which it is to be employed, although 50-foot lengths are handy when considerable

moving about is involved. Hose having an inside diameter of from three-eighths to five-eighths inch is the most convenient.

Where only a few trees or shrubs are to be protected and the tips of the tallest branches are not more than 10 feet from the ground, smaller sprayers are fairly convenient. One type of sprayer available for this purpose is the bucket pump. It should be made of brass or other noncorrosive metal and preferably should be equipped with an agitator. For convenience in spraying these pumps may be clamped to the bucket and operated by one person. For protecting a few plants hand atomizers are available. The best type of hand sprayer is made of brass, with a glass container having a capacity of about 1 quart.

The spray gun consists of a hollow metal rod from 2 to 4 feet long through which the spray may be thrown a distance of 10 to 30 feet, depending upon the pressure and the volume of the liquid. It can be adjusted to give a fine mist or a coarse spray. The mist spray covers the foliage most thoroughly, although the more distant foliage is best reached with the coarse spray. For covering tall shade trees there is a specially constructed spray gun utilizing high pressures which can be operated from the ground.

RECOMMENDATIONS FOR CONTROL IN COMMERCIAL PLANTINGS OF FRUIT[2]

The following recommendations for control are based on investigations covering a period of several years, during which countless numbers of poisonous materials in the form of dusts or sprays have been tried out in laboratory and orchard experiments. The methods given here are the most satisfactory from the standpoint of protection. Since control of the beetle depends upon the application of the material recommended, the reader should first become acquainted with the paragraphs dealing with the factors which influence control. In no case should fruit sprayed for the Japanese beetle be eaten until all residue from spraying has been removed.

APPLES

LATE VARIETIES

Late apples should be sprayed with 6 pounds of acid lead arsenate, 4 pounds of flour, and 100 gallons of water. One thorough application has usually been found sufficient for complete protection, but if followed by heavy rains a second application should be given two to three weeks later. (Fig. 6.)

EARLY VARIETIES

Unfortunately, certain early varieties of apples ripen at about the time the beetles appear in large numbers, and there is some danger from spray residue remaining on the fruit when arsenical sprays

[2] On account of the Federal laws limiting the amount of arsenic residue on fruit for market, fruit should not be sprayed with arsenical poisons within three to four weeks of harvest. The problem has been practically solved by washing the fruit in dilute hydrochloric acid, although this method can not be adopted for certain fruits, such as the peach. The world standard tolerance for arsenical residue on fruit is 0.01 gram per pound of fruit, and this regulation is enforced by the Food and Drug Administration of the U. S. Department of Agriculture.

are applied at this time. Where the residue on the fruit can be removed by washing or wiping, the treatment given for late apples is recommended. A nonpoisonous spray which has given some protection of early apples under conditions of light infestation is milk of lime from 12 pounds of unslaked lime or 16 pounds of hydrated lime to 100 gallons of water. This spray does not adhere well, however, and is easily washed off by rains. The application should be repeated if necessary. Any deposit, whether poisonous or nonpoisonous, must be removed from the fruit if it is to be marketed.

NONBEARING TREES

Nonbearing apple trees should be sprayed with 9 pounds of lead oleate coated lead arsenate to 100 gallons of water. This material remains on the foliage for a long time and is not readily washed off by rains.

FIGURE 6.—Sprayed and unsprayed apple trees in an orchard near Moorestown, N. J. Note the new growth on the tree defoliated by feeding of the Japanese beetle

PEACHES

YOUNG AND NONBEARING TREES

Young and nonbearing peach trees can be protected by thoroughly spraying the foliage not later than July 4 with a mixture of 3 pounds of lead arsenate and the milk of lime from 12 pounds of unslaked lime or 16 pounds of hydrated lime made up to 100 gallons with water. The application should be repeated from two to three weeks later.

LATE VARIETIES

As most of the injury to late peaches (Elberta or later varieties) is confined to the foliage, it is necessary to have the leaves espe-

cially well protected. An application of 25 pounds of dry mix, 10 pounds of hydrated lime, 3 pounds of lead arsenate, and 100 gallons of water should be given not later than July 4 in a season of normal weather conditons. It is much easier to protect trees when the foliage is dense and vigorous than when the trees are weak and undernourished.

EARLY VARIETIES

No sprays have been found to be effective against Japanese beetles on early varieties of peach trees (those varieties maturing before Elberta). The beetles are abundant in the orchards at the time early peaches are harvested and are especially attracted to the ripening fruit. (Fig. 7.) It has been impossible to eliminate this attractiveness by the use of chemicals; and insoluble spray materials, when applied at this time, leave a residue that can not be removed without injury to the fruit.

FIGURE 7.—Japanese beetles clustered on peach fruit. All the fleshy part of the fruit is destroyed, leaving only the pit. Early Rose is the variety of peach shown

Members of the research staff of the Japanese beetle laboratory have been making an extensive search for a nontoxic repellent which leaves no objectionable residue on the peach, but without success. The great attraction that the ripening peach has for the beetle has not been overcome.

Where the infestation is not too heavy, a spray consisting of milk of lime from 12 pounds of unslaked lime or 16 pounds of hydrated lime made up to 100 gallons with water has a definite repellent effect on the beetle, and may give complete protection over a period of several days. The application should not be repeated, however, as it leaves an objectionable visible residue, and unless removed by rains it reduces the market value of the fruit.

PLUMS

For the protection of plums the same recommendation is made as for peaches. The plums can be washed and all residue should be removed before the fruit is eaten or delivered at market.

CHERRIES

In a normal year the cherry crop in the heavily infested area is harvested before Japanese beetles have emerged in numbers large enough to cause any great injury either to the trees or to the crop. As spraying the trees just prior to harvesting the crop would result in excessive spray residue on the fruit, the application should be made just after the cherries are harvested. A second application may be necessary two to three weeks later. Lead oleate coated lead arsenate spray in the proportion of 9 pounds to 100 gallons of water should be used.

Where yellow leaf or leaf spot is present in an orchard, the usual 2½ gallons of commercial lime and sulphur concentrate solution to 100 gallons of water is recommended. Where this spray is applied immediately after the fruit has been harvested, 4 pounds of lead arsenate and 4 pounds of flour should be added for control of the Japanese beetle. This application should be repeated from two to three weeks later. Lead oleate coated lead arsenate should not be added to any spray mixture containing lime.

GRAPES

BEARING VINES

Six pounds of lead arsenate, 4 pounds of flour, and 100 gallons of water is recommended for the protection of bearing vines. As the beetles do not feed on the berries, it is only necessary to spray the leaves. The spray should be directed from the top down, using a very fine mist and coating each leaf thoroughly. Care must be taken not to force the spray up from below, as this might leave too much spray deposit on the berries when harvested. A second application should be made two to three weeks later in order to protect the new growth that comes out after the first spraying; otherwise beetles will accumulate upon it, and severe injury will result both to it and to other portions of the vines in spite of the spray coating.

YOUNG AND NONBEARING VINES

For the protection of young and nonbearing grapevines, 9 pounds of lead oleate coated lead arsenate to 100 gallons of water should be used, and the application repeated as often as necessary to protect the new growth.

Where the practice is to use the 4-6-50 Bordeaux mixture on grapes at about the time the beetle spray should be applied, the lead arsenate in the formula for the protection of bearing vines is added without the flour. Many varieties of grapes, such as Ives, are often seriously burned by heavy applications of Bordeaux mixture. In such cases it is suggested that the spray for Japanese beetles be composed of 6 pounds of lead arsenate, 4 pounds of flour, and 100 gallons of water.

SMALL FRUITS

On account of the objection to spray residue appearing on small fruits such as the raspberry and blackberry, protective sprays can not be applied until the fruit has been harvested. Recent experiments with certain varieties that produce two crops annually have shown that sprays can be applied as soon as the first crop has been picked without any injury to the second crop resulting from spray deposits. One application of lead oleate coated lead arsenate, 9 pounds to 100 gallons of water, after the crop has been harvested prevents further injury to the foliage and developing fruits.

RECOMMENDATIONS FOR CONTROL IN CITIES AND TOWNS

SHADE TREES

Certain shade trees (fig. 8) and ornamental plants which are favorite food plants of the beetle are grown extensively in the towns and cities in the heavily infested zone. The protection of these plants from injury has presented a difficult problem because few property owners are equipped to apply the sprays properly. Power spraying outfits are necessary to protect a tree over 10 feet in height. Property owners usually have only a few trees or ornamental plants to protect and are in no position to afford equipment of this nature.

FIGURE 8.—Elm tree injured by Japanese beetles. Note how the upper and outer portions of the tree have been defoliated

During recent years such situations have been met by communities undertaking or sponsoring a shade-tree-spraying campaign. Other communities and individuals have employed commercial spray companies to do the work. These arrangements have worked out quite satisfactorily. Details regarding the organization of the community spray program can be obtained from the local county agent.

The following shade trees should be sprayed with lead oleate coated lead arsenate, 9 pounds to 100 gallons of water, or, if small

quantities are to be made, 8 teaspoonfuls to each gallon of water, not later than July 4, with a second application from two to three weeks later: Linden (basswood), horsechestnut, elm, willow, Lombardy poplar, European white birch, Norway maple, sycamore, pin oak, chestnut oak, cypress, larch, and sassafras. Boxwood and magnolia are somewhat susceptible to injury from arsenicals, especially where heavy applications of lead arsenate are used. These plants should be covered with canvas to protect them from drift or drenchings while near-by trees are being sprayed.

SHRUBS AND ORNAMENTALS

The shrubs and ornamental plants likely to be injured as a result of beetle feeding are: Flowering quince, spirea, hawthorn, althea, buckeye, rose, hollyhock, dahlia, geranium, canna, evening primrose, zinnia, China-aster, hibiscus, and Virginia creeper. These plants should be treated with the lead oleate coated lead arsenate as described for the protection of shade trees. Where small quantities of spray solution are needed, 8 teaspoonfuls of lead oleate coated lead arsenate to each gallon of water should be used. All plants not over 10 feet in height can be sprayed with a hand or bucket pump sprayer in case power outfits are not available.

No satisfactory spray has yet been found, however, for the protection of the flowers, as it is not possible to keep the expanding bloom covered with a film of poison. Individual flowering plants, or groups of plants, can be protected by inclosing them with cloth mosquito netting. Frames for holding the netting can be constructed of wood or iron pipe at moderate cost. Several growers of choice roses have successfully protected their flowers by this method. Where mosquito netting is used, it may be necessary to make one or two applications of fungicide during July and August, because inclosed plants are more subject to mildew than plants grown in the open.

FRUIT TREES

Most of the fruit trees found in the cities and towns are considered in this circular as either shade trees or ornamental plants. Apple and cherry trees and grapevines can be treated as specified for shade trees. Peach and plum trees are somewhat susceptible to arsenical injury; therefore the lead arsenate in the spray for the protection of these trees should be 3 pounds to 100 gallons of water plus 16 pounds of hydrated lime. For smaller quantities of the spray solution 2 teaspoonfuls of lead arsenate and 8 teaspoonfuls of hydrated lime to each gallon of water should be used.

MISCELLANEOUS METHODS FOR DESTROYING BEETLES

The methods recommended in the foregoing paragraphs are intended for the protection of plants. Other methods have been worked out which are intended for the destruction of large numbers of beetles. They should be used, however, only when it is desired to reduce the infestation without regard to protection, and the protective sprays already described should never be omitted if there are plants that might suffer from attacks of the beetles.

JARRING

One of the easiest methods for destroying beetles on heavily infested plants is to jar the plants early in the morning (before 7 a. m.) when the temperature is low. The beetles fall to the ground, where they may be caught on sheets spread beneath the branches. They may then be killed by placing them in cans or buckets containing water and kerosene.

TRAPS[3]

A mechanical trap in which an attractive bait containing geraniol is used is effective in catching large numbers of beetles. The trap is of no value as a means of control, however, since it does not capture all the beetles attracted to it, and those beetles which are not captured increase the infestation in the neighborhood of the trap. At the present time traps can play no part in the protection of plants within the heavily infested area.

A CONTACT SPRAY[4]

Beetles can be destroyed with a spray which kills by contact. This spray is composed of sodium oleate and an alcoholic extract of pyrethrum flowers diluted with water. In using this spray it is necessary to wet the beetles thoroughly. The spray is harmless to foliage, but it does not prevent reinfestation.

GREEN LEAD ARSENATE[5]

There has been some objection to the conspicuous white deposit of lead arsenate that remains on plants after spraying, especially on shrubs and ornamentals. The unsightly residue can be avoided by using lead arsenate that has been colored green. Unfortunately, green lead arsenate is less repellent to beetles than ordinary white lead arsenate and more injury is caused by their feeding when it is used, although more beetles are killed.

AN ATTRACTIVE SPRAY[6]

Where destruction of beetles is desired rather than protection to foliage or fruits from beetle attacks, a spray consisting of green lead arsenate, sirup, emulsified geraniol, and water is recommended. Beetles will feed readily on this poisonous spray, but greater injury to the sprayed plants will result. Beetles will be attracted great distances and an increase in the volume of leaf area consumed will result from an increase in the natural population.

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[3] These traps and their operation have been described in U. S. Dept. Agr. Misc. Pub. 147, a copy of which can be obtained by addressing the U. S. Department of Agriculture, Washington, D. C.

[4] For information concerning the formula of this spray and its use for destroying beetles write the Japanese Beetle Laboratory at Moorestown, N. J., for Circular 92 of the New Jersey Department of Agriculture.

[5] For further information on the manufacture and use of green lead arsenate write to the Japanese Beetle Laboratory, Moorestown, N. J., for Circular 143 of the New Jersey Department of Agriculture.

[6] The formula for this spray and any other information not covered in this circular can be secured by addressing the Japanese Beetle Laboratory, Moorestown, N. J.

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